

1. INTRODUCTION

At GMT 2014-09-14, 257/02:08, the International Space Station (ISS) began a 3-minute, 44-second reboost using the ATV-5 thrusters. Figure 1 shows a Progress vehicle docked at the aftmost port in December of 2021. This was the docking location for the ATV-5 in September 2014, with its thrusters facing aftwards, which put thrust and the necessary orbital mechanics into play so as to speed up the ISS in its direction of flight. This directional acceleration increases velocity in the direction of flight resulting in a reboost of altitude of the space station.

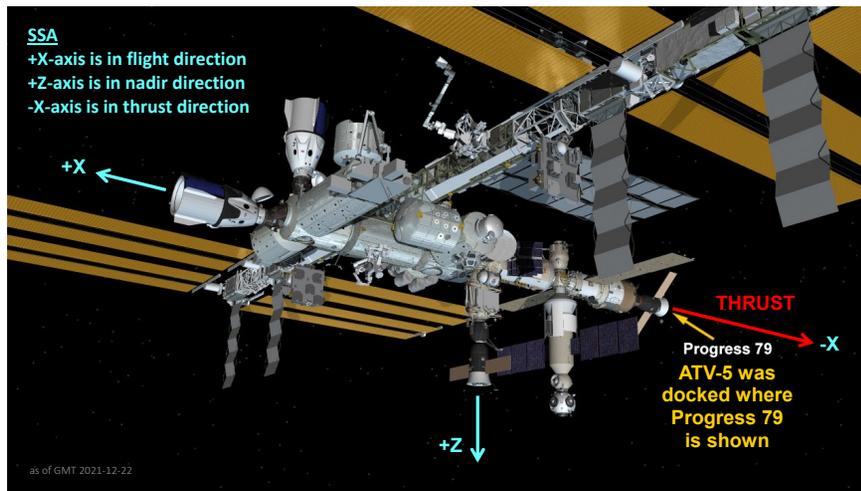


Fig. 1: ATV-5 was docked where Progress 79 is shown above during reboost.

2. QUALIFY

The information shown in Figure 2 was calculated from the Space Acceleration Measurement System (SAMS) sensor 121f08 measurements made in the Columbus module from a sensor mounting location on the European Physiology Module (EPM) COL1A3 rack. This color spectrogram plot shows increased structural vibration excitation contained mostly below 2 Hz or so, and approximately a 4-minute reboost (thruster firing) event itself that started just before the tick mark at GMT 02:08 and lasting a bit less than 4 minutes. We attribute much of the

structural vibration increase evident in the span of this spectrogram plot to Russian Segment (RS) attitude control since the as-flown timeline shows RS control from about GMT 00:30 to about 02:45. During this time, the RS thrusters were used for station attitude control leading into and just after the reboost activity. This is expected, and typical behavior. The increased structural vibrations are evident as more noticeable horizontal streaks (structural/spectral peaks) that change from quieter (green/blue) to more energetic (orange/red) sporadically during this period of RS control spanning about 135 minutes. The flare up of these nebulous horizontal (spectral peak) streaks are the tell-tale signatures of large space station appendages as they flex, twist, or bend in reaction to impulsive attitude control thruster forces. The actual reboost activity itself lasted less than 4 minutes as evidenced by slightly more pronounced, vertical orange-red streaks in Figure 2 starting just before GMT 02:08. For science operations and general situational awareness, it is prudent to be aware that the transient and vibratory environment (primarily below about 10 Hz or so) is impacted not only during the relatively short reboost event itself, but also during the much longer span of Russian Segment (RS) attitude control leading up to and sometime afterwards too. The difference being that during the reboost itself, the dominant factor might be considered to be the highly-directional step in the X-axis, while in the much longer case of RS attitude control, the dominant impact was the excitation of lower-frequency vibrational modes of large space station structures.

3. QUANTIFY

The as-flown timeline for this event indicated the reboost would start at GMT 02:08 and have a duration of 3 minutes and 44 seconds. Analysis of Space Acceleration Measurement System (SAMS) data recordings in the US LAB – see Figure 3 on page 4 – shows the tell-tale X-axis step that started at GMT 02:07:58 and had a duration of 3 minutes and 42 seconds. The data in this plot are 5-second interval average of the as-measured SAMS data.

Information from flight controllers indicated that this reboost event provided a space station rigid body ΔV of about 0.58 meters/second and the SAMS analysis indicated a value closer to 0.55 meters/second with red annotations in Figure 3, which nearly matched the expected value. The SAMS does not directly measure altitude, but flight controllers indicated that the ISS gained 0.96 km in altitude above the Earth.

Two more plots of interval average acceleration versus time for SAMS sensors distributed throughout the ISS are shown at the end of this document starting with

Figure 4 on page 4. Interval average processing was used to glean the “reboost step” signal feature from otherwise “noisy” measurements, and this processing effectively low-pass filtered the data so as to help emphasize the acceleration step that occurs on the X-axis during the reboost event. It should also be noted that we flipped the polarity of each axis (inverted each) in the SAMS plots owing to a polarity inversion issue inherent in SAMS transducers. A somewhat crude quantification of the reboost as measured by the distributed SAMS sensors is also given in Table 1. As expected, we saw fairly consistent impact measured by SAMS throughout the space station.

Table 1. **X-axis** steps (mg) during reboost event for 3 SAMS sensors.

Sensor	X-Axis	Location
121f03	0.252	LAB1O1 (ER2)
121f05	0.253	JPM1F1 (ER5)
121f08	0.255	COL1A3 (EPM)

4. CONCLUSION

The SAMS measurements for 3 sensor heads distributed across all 3 main labs of the ISS were analyzed and showed an **X-axis step during the ATV-5 reboost of just over 0.2 mg**. Furthermore, calculations based on SAMS sensor (121f03) mounted on EXPRESS Rack 2 (LAB1O1) in the US LAB indicate a ΔV metric of about 0.55 meters/second was achieved, and this result nearly matched flight controllers’ value of 0.58 meters/second.

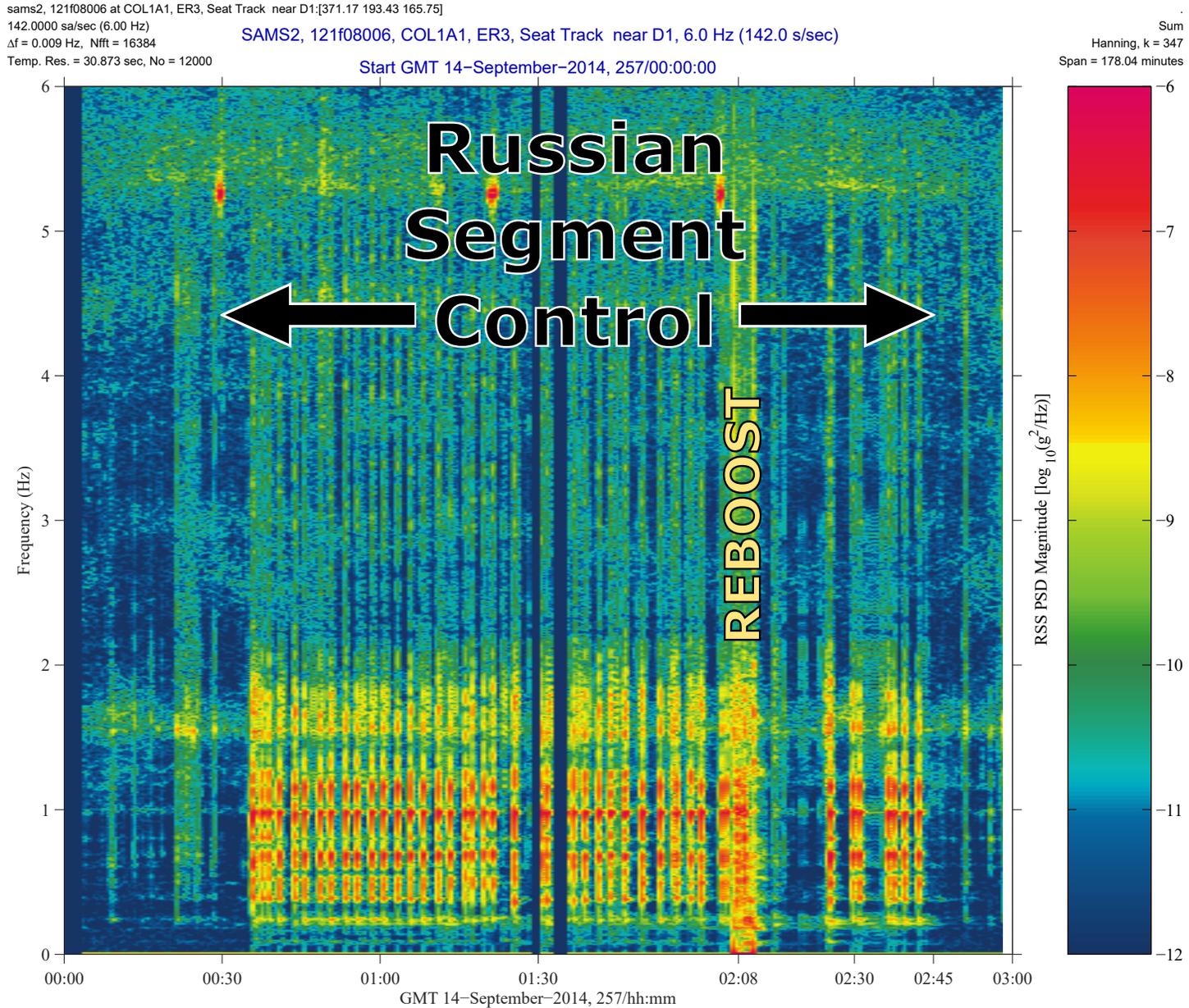


Fig. 2: Spectrogram showing ATV-5 Reboost on GMT 2014-09-14.

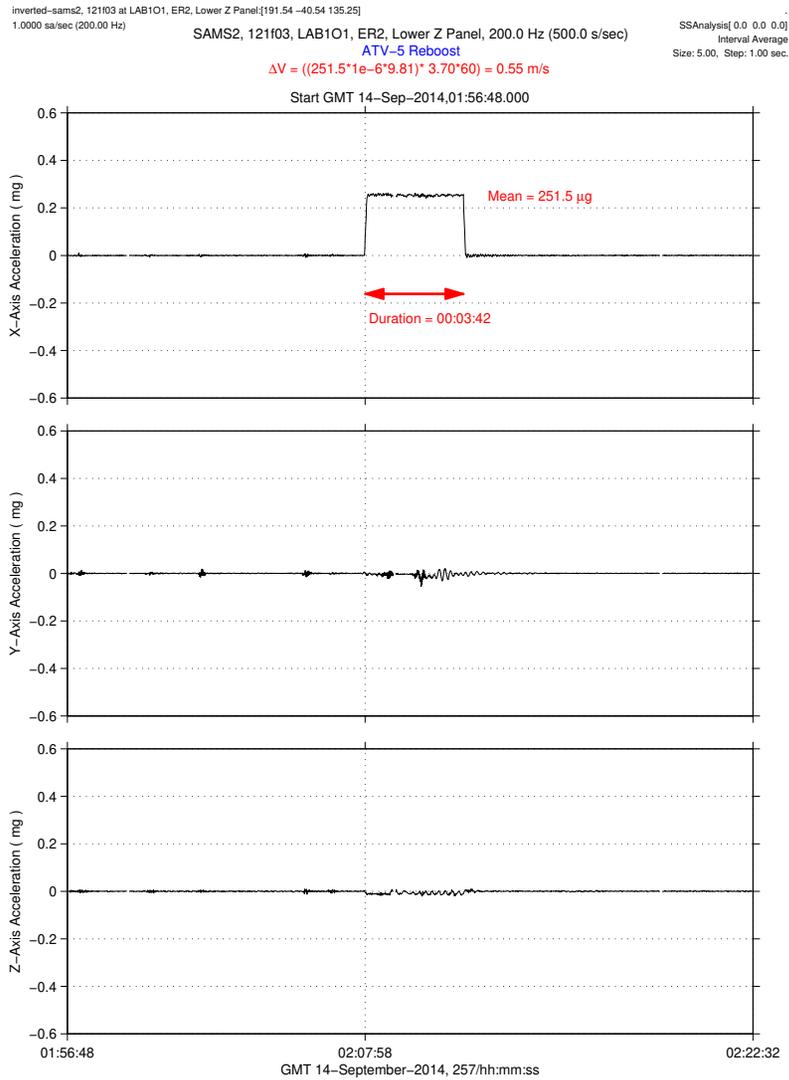


Fig. 3: 5-sec interval average for SAMS 121f03 sensor in the LAB.

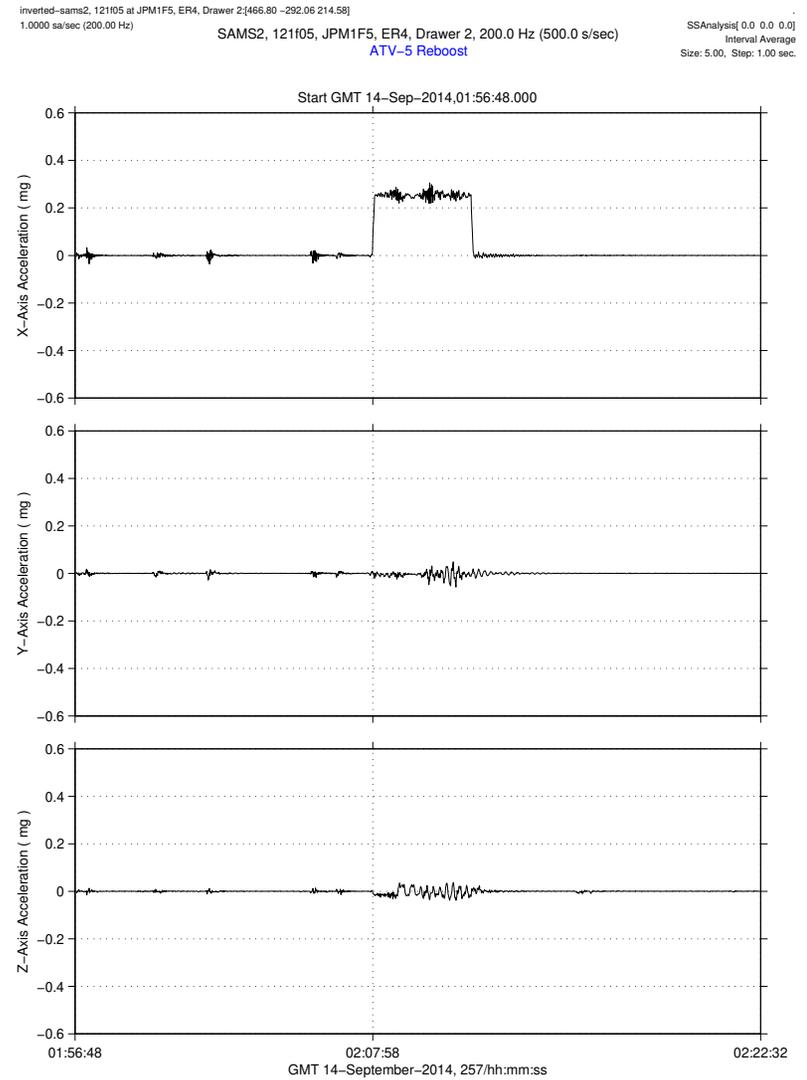


Fig. 4: 5-sec interval average for SAMS 121f05 sensor in the JEM.

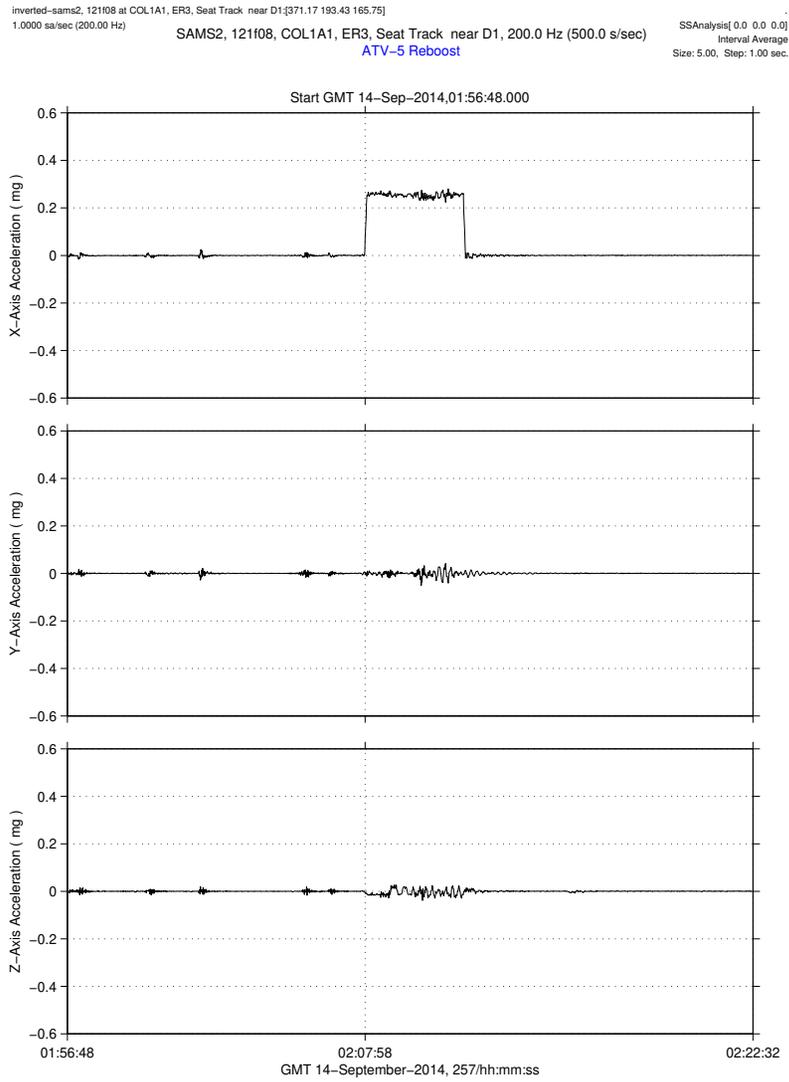


Fig. 5: 5-sec interval average for SAMS 121f08 sensor in the COL.